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Intensive Surveillance of Femoropopliteal-Tibial Autogenous Vein Bypasses Improves Long-Term Graft Patency and Limb Salvage

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Objective

The authors determined the impact of an intensive surveillance program of autogenous vein bypasses on patency and limb salvage.

Summary Background Data

Surveillance protocols of vein bypasses can identify graft-threatening lesions to permit elective revisions before thrombosis. The authors compared follow-up based on clinically indicated procedures with intensive surveillance.

Methods

From 1985 to 1994, 615 autogenous vein bypasses (454 *in situ*, 161 reversed/composite) to popliteal (n = 169) and tibial (n = 446) arteries were performed for critical limb ischemia (n = 507), claudication (n = 88), and popliteal aneurysm (n = 20). Intensive surveillance of autogenous vein bypasses consisted of ankle brachial index and duplex scan with graft velocities measured at 1 month, 3 months, 6 months, and every 6 months subsequently. After surgery 317 bypasses had intensive surveillance, 222 bypasses were clinically indicated for follow-up, and 76 bypasses were excluded because follow-up or patency was less than 31 days.

Results

Primary patency at 5 years was similar for bypasses treated by intensive surveillance (56%) and those treated with clinically indicated procedures (67%). Secondary patency and limb salvage at 5 years was significantly improved ($p < 0.02$) for bypasses followed by intensive surveillance (80% and 94%) compared with clinically indicated procedures (67% and 73%). Revision of patent bypasses was higher ($p < 0.000001$) for bypasses treated by intensive surveillance (61 of 70, 87%) compared with those treated with clinically indicated procedures (9 of 34, 26%). Secondary patency at 2 years was significantly higher ($p < 0.02$) for revision of patent bypasses (79%) compared with thrombosed bypasses (55%).

Conclusions

Long-term autogenous vein bypass patency and limb salvage is significantly improved by intensive surveillance, permitting identification and correction of graft threatening lesions before thrombosis.

Bypasses from the femoral to the popliteal or tibial arteries, whether using the *in situ* or reversed saphenous vein, increase limb salvage in patients with critical ischemia. Superior results using these bypass procedures are achieved with meticulous surgical technique and the presence of an adequate venous conduit. Postoperative surveillance of autogenous vein bypasses has become widely accepted to monitor bypass graft function and patency. Szilagyi[1] was the first to emphasize that lesions develop in the vein bypass conduit that lead to thromboses. Surveillance of the autogenous vein bypasses can lead to the detection of the stenotic lesions and permit revision before thrombosis, significantly improving long-term bypass graft patency and limb salvage.[2-4] The initial studies of bypass graft surveillance used clinical examination ankle brachial indices (ABI), with abnormal results leading to arteriography to detect the graft-threatening lesions.[5-8] Autogenous vein bypass graft surveillance by this method yielded a 5-year patency rate of 76% to 82%, with the value of monitoring ABIs in asymptomatic patients questioned by some investigators.[9] More recently, surveillance of autogenous vein bypasses included monitoring graft flow velocities and complete duplex scanning of the bypass conduit, in addition to clinical examination and ABIs.[10-13] However, the 5-year patency rates of surveillance with ABIs and duplex scan are approximately 80%,[2-4,14-16] similar to that reported by the use of clinical examination or ABIs alone. Duplex scan surveillance has been shown to be more reliable in localizing the stenoses than clinical examination or ABIs. However, the reason for surveillance is not just to detect stenotic lesions, but to predict which ones significantly threaten graft patency and need revision to maintain graft patency and limb salvage.[17-20] The purpose of this study was to compare autogenous vein bypasses treated by an intensive surveillance protocol by serial duplex scans and ABIs with those treated by clinically indicated procedures, to determine the effect on long-term graft patency and limb salvage.

MATERIALS AND METHODS

From January 1985 to August 1994, we performed 615 autogenous vein bypasses to the popliteal (n = 169) and tibial (n = 446) artery. The *in situ* saphenous vein bypass was the preferred technique, as previously described,[21] and was used in 454 patients. Reverse autogenous vein or composite vein bypasses were used in 161 patients. Indications for the bypass were critical limb ischemia (n = 507), claudication (n = 88), and popliteal aneurysm (n = 20).

The 615 autogenous vein bypasses were analyzed according to the method of follow-up. Intensive surveillance was performed postoperatively in 317 patients. Intensive surveillance of autogenous vein bypasses consisted of ankle brachial index (ABI) and duplex scan with graft velocities measured at 1, 3, and 6 months and every 6 months subsequently. Duplex scan was performed of the entire graft length for identification of stenotic areas and determination of graft velocities. Two hundred twenty-two autogenous vein bypasses underwent follow-up based on a clinically indicated procedure. This group had procedures or diagnostic studies performed as indicated by the recurrence of symptoms of claudication or critical limb ischemia, change on physical examination, or a significant change in the ABI. Duplex scan with graft velocities were performed intermittently in this group, but the timing of the procedures did not satisfy the criteria for intensive surveillance. Because we were interested in determining the impact of intensive surveillance of autogenous vein bypasses on long-term patency and limb salvage, 76 bypasses were excluded because graft patency or follow-up was less than 31 days (n = 50) or the patients were unable to be observed for follow-up (n = 26). The preoperative evaluation, age, sex, risk factors, indications, bypass conduit, and the results of the follow-up procedures and reasons for revision were noted for patients undergoing intensive surveillance and clinically indicated procedures. The inflow artery for the 317 autogenous vein bypasses treated by intensive surveillance was the common femoral artery (n = 293), profunda femoris artery (n = 2), reconstructed femoral artery (n = 2), superficial femoral artery (n = 7), and popliteal artery (n = 23). The outflow artery was the popliteal artery (n = 115), anterior tibial artery (n = 55), posterior tibial artery (n = 82), peroneal artery (n = 35), and dorsalis pedis artery (n = 30). For the 222 patients with autogenous vein bypasses undergoing clinically indicated procedures, the inflow artery was the common femoral artery (n = 171), profunda femoris artery (n = 3), reconstructed femoral artery (n = 5), superficial femoral artery (n = 14), and popliteal artery (n = 29). The outflow artery included the popliteal artery (n = 37), the anterior tibial artery (n = 54), posterior tibial artery (n = 54), peroneal artery (n = 37), and dorsalis pedis artery (n = 40).

Long-term graft patency, graft revision, and limb salvage were determined. The life-table method was used to analyze primary and secondary patency in limb salvage for all bypasses. The life-table bypass graft patency and limb salvage rates were calculated from the date of last examination according the criteria of the Society for Vascular Surgery and the International Society of Cardiovascular Surgery.[22] Patient survival and amputation

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Table 1. CHARACTERISTICS OF PATIENTS UNDERGOING VEIN BYPASS

Characteristics	Intensive Surveillance (n = 317)	Clinical Indications (n = 222)
Age (yrs)	65 ± 18	65 ± 17
Sex		
Male (%)	203 (64)	139 (63)
Female (%)	114 (36)	83 (37)
Risk factors		
Smoking (%)	237 (75)	132 (59)*
Diabetes (%)	148 (47)	118 (53)
Hypertension (%)	181 (57)	134 (60)
Cardiac disease (%)	147 (46)	120 (54)
Indications		
Critical ischemia (%)	232 (73)	205 (92)*
Claudication (%)	72 (23)	13 (6)*
Popliteal aneurysm (%)	13 (4)	4 (2)
Preoperative ABI	0.43 ± 0.17	0.43 ± 0.18
Postoperative ABI	0.97 ± 0.09	0.93 ± 0.16
Bypass Conduit		
In situ (%)	232 (73)	168 (76)
Non-*in situ* (%)	85 (27)	54 (24)

ABI = ankle brachial indices.
* $p < 0.0001$, compared with intensive surveillance.

were determined by their last follow-up or by telephone. An amputation was determined to be major when performed above the metatarsal level.

Data Analysis

The association of variables including risk factors, indications, and revision of patent or thrombosed bypass conduits were compared with two way contingency tables, and statistical significance was determined with the use of chi square test. The life-table patency and limb salvage rates were compared with the use of Mantel-Haenszel Test for the comparison of life-table curves.

RESULTS

The cumulative survival rate was 91% at 1 year, 87% at 2 years, 82% at 3 years, 74% at 4 years, 74% at 5 years, and 61% at 6 years. The characteristics of the patient undergoing autogenous saphenous vein bypasses who were treated by intensive surveillance were compared with follow-up by clinically indicated procedures (Table 1). Patients undergoing an intensive surveillance program had a significantly higher incidence of smoking. There was no significant difference in age, sex, or other risk factors between the two groups. Patients undergoing intensive surveillance also had a significantly higher number of bypasses performed for claudication and a significantly lower number of bypasses performed for critical limb ischemia. Of the 232 bypasses treated by intensive surveillance performed for critical limb ischemia, 121 patients had rest pain and 111 had tissue necrosis. Of the 205 bypasses performed in patients treated by clinically indicated procedures, 71 had rest pain and 134 had tissue necrosis. The degree of ischemia as determined by the preoperative ABI was similar between the two groups. There was no significant difference in the type of bypass conduit used between the two groups. For intensive surveillance, the non-*in situ* bypasses included reversed saphenous vein (n = 71, 22%), reversed cephalic vein (n = 2, 1%), and modified/composite vein (n = 12, 4%). For clinically indicated procedures, the non-*in situ* bypasses included reversed saphenous (n = 38, 17%), reversed cephalic vein (n = 1, 1%), and modified/composite vein (n = 6, 6%).

For bypasses treated via intensive surveillance, the average number of surveillance studies performed was 6.8 ± 4.9, with an average interval between the studies of 2.5 ± 1.2 months. For bypasses treated by clinically indicated procedures, with intermittent ABIs and duplex scanning with graft velocities, the average number of studies was 2.1 ± 1.8, with an average interval between the studies of 8.7 ± 10.8 months. The primary patency was not significantly different for bypasses treated by intensive surveillance compared with follow-up by clinically indicated procedures (Table 2). However, the secondary patency was significantly improved for bypasses treated by intensive surveillance compared with clinically indicated procedures (Table 3, Fig. 1). The secondary long-term bypass graft patency, as determined by life-table analysis, was not significantly different for bypasses treated by intensive surveillance performed for claudication (81% at 42 months, SE = 9.4) compared with other indications (81% at 42 months, SE = 6.2). Similarly, the limb salvage rate also was significantly improved for extremities with bypasses treated by intensive surveillance compared with clinically indicated procedures (Fig. 2). No amputations were performed of patient extremities with bypasses for claudication and treated by clinically indicated procedures or intensive surveillance. Excluding all bypasses performed for claudication, the limb salvage rate at 5 years remained significantly improved ($p < 0.02$) for bypasses treated by intensive surveillance (92%, SE = 6.1) compared with bypasses treated by clinically indicated procedures (73%, SE = 7.7).

The improved secondary patency and limb salvage was due to the detection and correction of graft threatening lesions before thrombosis. Revision of patent bypasses was higher ($p < 0.000001$) for bypasses treated by intensive surveillance (61/70, 87%) compared with bypasses treated by clinically indicated procedures (9/34, 26%). Fifty-six of the 61 bypasses treated by intensive

Table 2. PRIMARY PATENCY RATE OF AUTOGENOUS VEIN BYPASSES

Interval (mo)	No. at Risk	No. Failed	No. Withdrawn	Interval Patency Rate	Cumulative Patency (%)	SE (%)
Intensive surveillance						
1-6	317	54	58	0.82	82	
6-12	205	20	41	0.90	74	
12-18	144	10	42	0.93	69	
18-24	92	2	21	0.98	68	
24-30	69	3	18	0.96	65	
30-36	48	1	13	0.98	64	
36-42	34	0	12	1.00	64	
42-48	22	0	5	1.00	64	
48-54	17	1	1	0.94	60	
54-60	15	1	3	0.93	56	9.6
Follow-up by clinically indicated procedures*						
1-6	222	37	29	0.84	84	
6-12	156	7	23	0.96	81	
12-18	126	8	22	0.94	76	
18-24	96	5	18	0.95	72	
24-30	73	3	11	0.96	69	
30-36	59	2	14	0.97	67	
36-42	43	0	9	1.00	67	
42-48	34	0	6	1.00	67	
48-54	28	0	10	1.00	67	
54-60	18	0	1	1.00	67	9.1

* No significance difference compared with intensive surveillance.

surveillance that were patent at time of revision were performed because of graft-threatening lesions detected by a significant change in the ABI or graft velocity. Of the 56 patent bypasses undergoing revision, the graft-threatening lesion was detected by both the ABI and duplex scan in 32 cases, duplex scan alone in 9 cases, and a significant change in the ABIs in 15 cases. Only four of nine bypasses treated by clinically indicated procedures that were patent at time of revision had the detection of a graft-threatening lesion by ABIs alone in one case, graft velocities alone in two cases, or both in one case, performed because of changes in the signs or symptoms of the patient ($p < 0.001$ compared with intensive surveillance). Secondary patency at 2 years was significantly higher for bypasses revised while patent, compared with thrombosed bypasses (Table 4, Fig. 3).

The reason for revision of patent bypasses and the site of the graft-threatening lesions are shown for both groups in Table 5, divided according to the secondary procedure. The graft-threatening lesions were detected and corrected before the onset of symptoms in 56 (92%) of 61 of the bypasses treated by intensive surveillance. Only four (45%) of the nine bypasses undergoing revision of patent bypasses during follow-up by clinically indicated procedures had no symptoms ($p < 0.001$ compared with intensive surveillance). Intensive surveillance most commonly detected graft-threatening lesions along the vein conduit and at anastomotic sites (Table 5). Follow-up by clinically indicated procedures most commonly detected graft-threatening lesions involving the adjacent arteries ($p < 0.03$ compared with intensive surveillance). For bypasses patent at the time of revision, the preoperative ABI and graft velocities were improved after revision for both groups. For bypasses treated by intensive surveillance, the ABI before revision was 0.72 ± 0.53 and improved to 1.03 ± 0.48 after revision. Prerevision graft velocity was 45 ± 13 cm/second and improved to 59 ± 17 cm/second after revision. The peak systolic velocity was 261 ± 43 cm/second and the velocity ratio (V1/V2) was 5.5 ± 2 for graft-threatening stenotic lesions along the vein conduit before revision. For bypasses treated by clinically indicated procedures, the prerevision ABI was 0.54 ± 0.14, and the postrevision ABI was 0.87 ± 0.11; the prerevision graft velocity was 43 ± 19 cm/second and postrevision graft velocity was 64 ± 19 cm/second.

Nine bypasses treated by intensive surveillance were thrombosed at the time of revision. Eight of the nine revisions of thrombosed bypasses were performed within 1 month of the original bypass operation, with long-term bypass patency maintained and subsequently treated by intensive surveillance. The eight autogenous vein bypasses that were thrombosed and revised in the perioperative period included one with a hypercoagulable state (protein S deficiency), one with a distal anastomotic ste-

Table 3. SECONDARY PATENCY RATE OF AUTOGENOUS VEIN BYPASSES

Interval (mo)	No. at Risk	No. Failed	No. Withdrawn	Interval Patency Rate	Cumulative Patency (%)	SE (%)
Intensive surveillance						
1-6	317	16	69	0.94	94	
6-12	232	11	47	0.95	89	
12-18	174	7	54	0.96	85	
18-24	113	1	31	0.99	84	
24-30	81	2	19	0.98	82	
30-36	60	0	16	1.00	82	
36-42	44	1	14	0.98	80	
42-48	29	0	8	1.00	80	
48-54	21	0	1	1.00	80	
54-60	20	0	5	1.00	80	8.0
Follow-up by clinically indicated procedures*						
1-6	222	25	53	0.88	88	
6-12	144	6	25	0.96	84	
12-18	113	4	21	0.96	81	
18-24	88	4	12	0.95	77	
24-30	72	3	14	0.96	74	
30-36	55	0	11	1.00	74	
36-42	44	0	9	1.00	74	
42-48	35	0	12	1.00	74	
48-54	23	0	2	1.00	74	
54-60	21	2	4	0.90	67	8.4

* $p < 0.02$ compared with intensive surveillance.

nosis, one with a sclerotic valve segment, and five bypasses in which the cause was unknown. Thus, only one autogenous vein bypass treated by intensive surveillance thrombosed before revision outside the perioperative period. This patient had significant decrease in ABI and long-segment graft stenosis noted by duplex scan 4 months after bypass, however, thrombosed before the planned date of revision. The revision procedures in these nine bypasses were interposition saphenous vein graft (n = 2), vein patch angioplasty (n = 2), jump graft (n = 2), primary repair (n = 1), and thrombectomy alone (n = 2). Twenty-five bypasses undergoing follow-up by

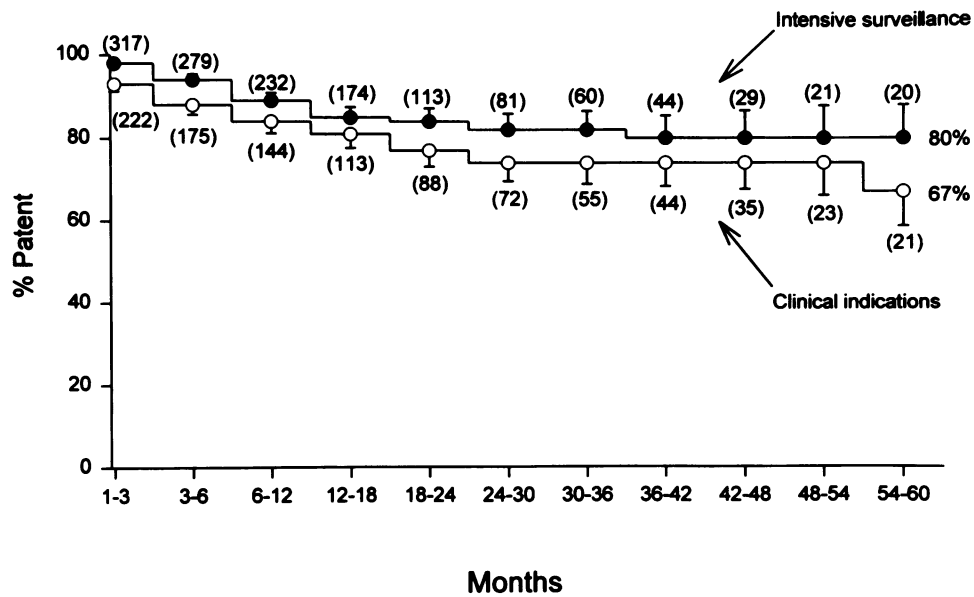

Figure 1. Autogenous vein bypass grafts followed by intensive surveillance (closed circles) had a significantly higher ($p < 0.02$) secondary patency rate compared with follow-up by clinically indicated procedures (open circles).

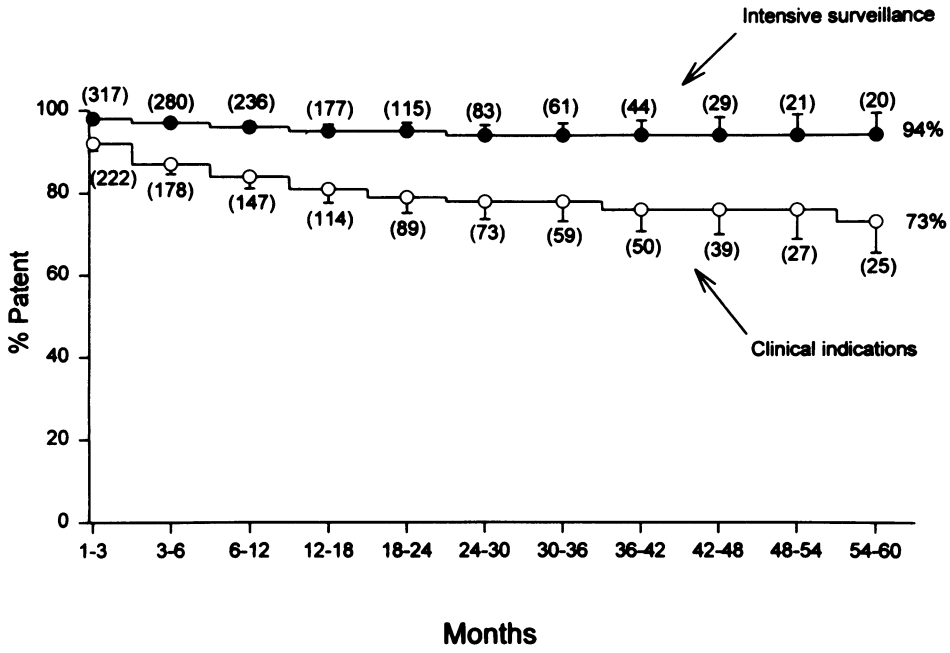

Figure 2. Patients with grafts followed by intensive surveillance (closed circles) had a significantly higher ($p < 0.02$) limb salvage rate compared with follow-up by clinically indicated procedures (open circles).

clinically indicated procedures were thrombosed at the time of revision. Four of the bypasses were thrombosed and revised within 1 month of the bypass operation. Graft-threatening lesions included distal anastomotic stenoses (n = 4), progression of outflow disease (n = 1), embolus (n = 1), and an unknown cause (n = 19). Three of these bypasses had a known decrease in ABI before revision. Bypass procedures included interposition saphenous vein graft (n = 3), primary repair and thrombectomy (n = 15), jump graft (n = 3), and vein patch angioplasty (n = 4).

To determine the value of continuous long-term surveillance, long-term patency, and the incidence of revisions of autogenous vein bypasses that had normal initial postoperative studies (ABI > 0.9, peak systolic velocity > 45 cm/second, no > 50% stenosis) were compared with those with abnormal results. Of the 222 autogenous vein bypasses treated by clinically indicated procedures, 97 had graft surveillance performed at sporadic intervals, with the average date of the first study 6.4 ± 9.7 months postoperatively. Sixty-one autogenous vein bypasses had normal initial studies, and 36 were abnormal. The secondary patency rate, as determined by life-table analysis at 30 months, was not significantly different for bypasses with normal initial

Table 4. PATENCY RATE OF AUTOGENOUS VEIN BYPASSES UNDERGOING REVISION

Interval (mo)	No. at Risk	No. Failed	No. Withdrawn	Interval Patency Rate	Cumulative Patency (%)	SE (%)
Patent at time of revision						
1-3	70	0	2	1.00	100	
3-6	68	4	6	0.94	94	
6-12	58	7	8	0.88	83	
12-18	43	2	11	0.95	79	
18-24	30	0	10	1.00	79	6.6
Thrombosed at time of revision*						
1-3	34	5	4	0.85	85	
3-6	25	4	1	0.84	71	
6-12	20	3	2	0.85	60	
12-18	15	0	2	1.00	60	
18-24	13	1	1	0.92	55	10.2

* $p < 0.02$ compared with patient at time of revision.

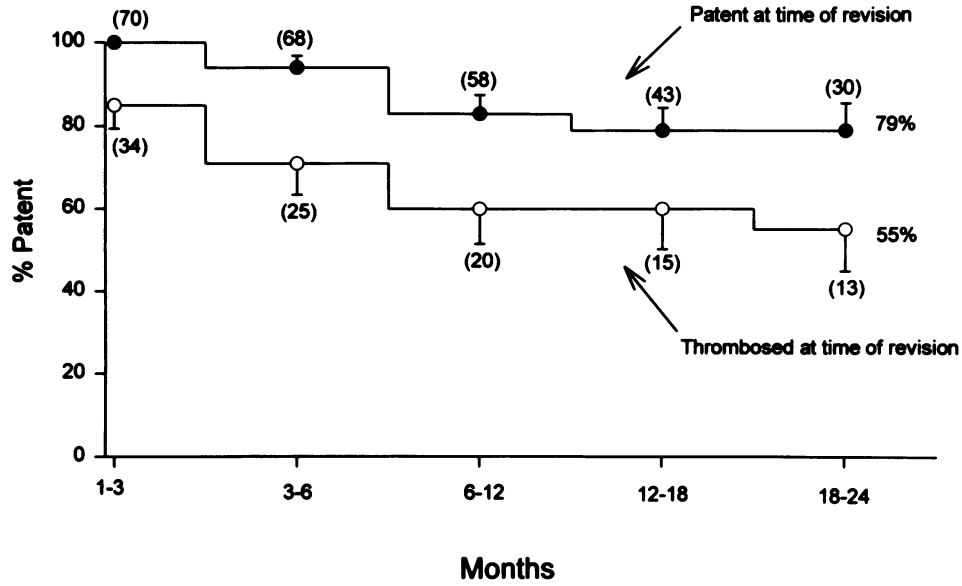

Figure 3. Autogenous vein bypasses patent at time of revision (closed circles) had a significantly higher ($p < 0.02$) patency rate compared with bypasses thrombosed at time of revision (open circles).

study (84%, SE = 5.8) as compared with bypasses with an abnormal initial study (76%, SE = 9.3). Of the 317 bypasses treated by intensive surveillance, 76 had an abnormal initial study and 241 had a normal initial study performed 1 month postoperatively. Seven of the 241 autogenous vein bypasses had abnormal duplex scans within 1 month that required revision to achieve an ABI of > 0.9 and to normalize the duplex scan study at 1 month. The secondary patency at 30 months was significantly higher ($p < 0.005$) for bypasses with normal initial study (85%, SE = 3.9) as compared with bypasses with an abnormal initial study (73%, SE = 12.6). The presence of an ABI > 0.9 and a normal duplex scan at 1 month, however, did not equate with the long-term absence of the development of graft-

Table 5. REVISIONS OF PATENT AUTOGENOUS VEIN BYPASSES

	Reason for Revision		Site of Lesion		
Secondary Procedure	ABI/Graft Velocity	Recurrent Symptoms	Vein Conduit	Anastomosis	Adjacent Artery
Intensive surveillance					
Primary repair	4	—	3	1	—
Vein patch	26	1	23	4	—
Interposition graft	6	—	6	—	—
Jump graft	11	4	2	10	3
Ligation AVF	6	—	6	—	—
PTA/Inflow bypass*	3	—	—	—	3
Total (%)	56 (92)	5 (8)	40 (66)	15 (24)	6 (10)
Follow-up by clinically indicated procedures					
Primary repair	—	—	—	—	—
Vein patch	2	—	2	—	—
Interposition graft	1	—	—	1	—
Jump graft	—	5	—	1	4
Ligation AVF	1	—	1	—	—
PTA/Inflow bypass	—	—	—	—	—
Total (%)	4 (45)†	5 (55)	3 (33)	2 (22)	4 (45)‡

ABI = ankle brachial indices; AVF = arteriovenous fistula.
* Two iliac artery percutaneous transluminal angioplasties (PTA), one femoro-femoral bypass.
† $p < 0.001$ and ‡$p < 0.03$ compared with intensive surveillance.

threatening lesions. Thirty-nine bypasses with normal duplex scans and ABI > 0.9 did developed graft-threatening lesions with significant changes in their duplex scans and ABI. Of the bypass grafts in the intensive surveillance program that underwent revision, the ABI was 0.95 ± 0.12 at 1 month. The prerevision ABI was significantly lower at 0.74 ± 0.50. Even in the presence of an ABI > 0.9 and normal duplex scan at 1 month, 16 bypasses developed graft-threatening lesions, requiring revision within 6 months; 16 bypasses underwent revision between 6 months and 18 months; 3 bypasses had revision between 18 months and 3 years; and 4 bypasses developed graft-threatening lesions, requiring revision after more than 3 years of follow-up. For bypasses in the intensive surveillance program with normal graft duplex scan and ABI > 0.9, the incidence of graft-threatening lesions developing that required revision did decrease with time, but the need for revision continued throughout the follow-up period.

DISCUSSION

In this study, an intensive surveillance program of autogenous vein bypasses, as compared with clinically indicated procedures, did significantly increase long-term graft patency and limb salvage. The improved results were partially the result of the detection and revision of graft-threatening lesions before thrombosis with the intensive surveillance program. The secondary patency rates was significantly decreased for bypasses thrombosed at time of revision, as compared with patent bypass revisions.[8,14,16] The importance of the surveillance protocol was to monitor the graft and limb hemodynamics, to ensure the maintenance of normal graft hemodynamics, or to detect abnormal hemodynamics of failing bypasses. The identification and correction of graft-threatening lesions did normalize the graft hemodynamics in this and other reports,[2,16] significantly improving both the long-term graft patency and limb salvage.

This study has several limitations. It was not a randomized study; although the surveillance and clinical follow-up were performed prospectively, the data were analyzed retrospectively. The follow-up was dependent primarily on the patient's location and ability to return for follow-up, as well as the patient's compliance. Patients undergoing bypass for claudication were more likely to fulfill the intensive surveillance program, but this did not significantly effect graft patency and limb salvage results. In addition, the intervals between follow-up visits were longer for those treated by clinically indicated procedures *versus* intensive surveillance. However, despite these limitations, the bypass graft patency and limb salvage rates were similar to other recent reports with follow-up by clinical indications or ABIs[4,9,12,17] and those undergoing an intensive surveillance program.[4,12,18,20,21] The major strength of this study comparing intensive surveillance and follow-up by clinically indicated procedures of autogenous vein bypasses was that an adequate number of bypasses[23] were analyzed to determine a significant difference in graft patency and limb salvage from a single institution by the same surgeons during the same time interval.

The intensive surveillance program did permit detection of graft-threatening lesions and revision before thromboses. No patent graft in this study with a normal ABI and duplex scan thrombosed before the next surveillance study. Most stenotic lesions occurred within 18 months of the bypass procedure along the vein conduit,[24,25] emphasizing that the quality of the vein is the most important predictor of long-term patency.[26] In this study, significant changes in the ABIs or duplex scan were used to recognize the presence of graft or anastomotic stenosis or progression of arterial disease, emphasizing that the use of both duplex scanning and ABIs was the best method of surveillance.

We were unable to determine an absolute time interval postoperatively in which it would be safe to stop the intensive surveillance program. Although the incidence of graft threatening lesions did decrease with time,[2,24] graft-threatening lesions continue to develop. Even with follow-up beyond 5 years, the atherosclerotic disease process continues to produce graft-threatening lesions along the vein conduit and adjacent arteries that necessitate revision.[27] A single determination of a normal postoperative duplex scan and ABI was not an adequate predictor of which bypasses would develop graft stenosis or failure. The true value of the surveillance program was the serial measurements, permitting the detection of significant changes in the ABIs or graft velocities, and the subsequent revision of graft-threatening lesions in failing grafts before thrombosis, thus significantly improving long-term graft patency and limb salvage.

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Discussion

DR. JOHN MANNICK (Boston, Massachusetts): Ladies and Gentlemen, I very much enjoyed this paper because it supports a long-standing conviction of mine, and that is, one of the bigger favors vascular surgeons can do for their patients is to fix stenotic vein grafts before they clot. This is a pretty simple operation, and, as my colleague, Andy Whittemore, pointed out about 15 years ago, vein grafts that are repaired before they thrombose go on to very good long-term patency, about 80%. Whereas, those that clot and then have the same sort of lesion repaired don't do very well at all.

Dr. Richardson and his group have done a lot better with clotted vein grafts than we have in Boston, and I congratulate him and his associates for a 55% patency rate in these grafts. Now it's been argued that surveillance techniques really don't help very much in finding the grafts that are about to thrombose. I suspect that the evidence we have heard today, coupled with a lot of other recent reports in the literature, will put that to rest. The present report probably doesn't absolutely prove the case because it's not a prospective study.

On the other hand, the finding that Dr. Richardson pointed out very well in his presentation, that the group was able to find almost all of their grafts in the intensive surveillance group that needed repair before they thrombosed, as opposed to the other group where most of the failing grafts were thrombosed when they had to reoperate on them, ought to prove the point, it seems to me. Certainly, our own experience, which is not prospective either, suggests that when we began duplex surveillance of grafts, we were reoperating on about 10% of vein grafts when they were still patent and we are now operating on about 20% of our patients with patent grafts and finding that our thrombosed grafts or unexpected thromboses have dropped to near 0%. So I think this is all in support of the idea that duplex surveillance is a worthwhile undertaking.

I do have a couple of questions for Dr. Richardson and his associates. The first is that as those two patency curves, that is, the intensive surveillance curve and the clinical indications curves go out over the years, they remain pretty close until about 6 months before the 5-year interval, and then they drop off. And there seem to be only two patients out there in the clinical indications group that lost their grafts that accounted for this fairly substantial difference in 5 years. But this all occurred between four and a half and five years, not a time when many vein grafts fail, as I am sure the authors would agree. So I'd like to know what happened to those two grafts and whether these two curves were statistically significantly different before the 5-year interval. The second question I'd like to ask him is what criteria do they use for a failing graft by duplex scan? We have picked about a 70% stenosis as being something we'd prefer to fix. What do they think? Again, I enjoyed this presentation, and I thank them for letting me read the manuscript before I got up here.

DR. THOMAS DODSON (Atlanta, Georgia): Dr. Williams, Dr. Copeland, Members and Guests. Vascular surgery is a relatively new and rapidly evolving field. Kunlin in 1948 did the first reversed saphenous vein. Charles Rob, at the behest of a visiting guest, did the first *in situ* bypass in 1959. Szilagyi, faced with burgeoning numbers of grafts, was the first, in 1973, to evaluate reversed saphenous vein grafts by arteriography. Since that time, many individuals have evaluated various modalities of graft surveillance. Notable examples are the ABI assessment, duplex scanning and color-flow duplex scanning most recently.